



Status of the DCBA/MTD experiment

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$\beta\beta$ experiments in the world

Scintillation/Calorimetry

ionization
COBRA (^{130}Te , ^{116}Cd , etc.)
Majorana(^{76}Ge)
GERDA(^{76}Ge)

scintillation
CANDLES(^{48}Ca)
MOON(^{100}Mo)
KamLAND-Zen(^{136}Xe)
SNO+ (^{150}Nd)

bolometry
CUORE(^{130}Te)

Ionization
+scintillation
EXO(^{136}Xe)
NEXT(^{136}Xe)

Combination

NEMO3 (^{100}Mo , ^{82}Se , ^{150}Nd , etc.)
Super NEMO (^{82}Se , ^{150}Nd , etc.)

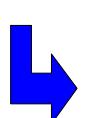
Tracking (momentum reco.)

DCBA (^{100}Mo ,
 ^{150}Nd , etc.)

(Dis-)Advantages of Tracking method

Advantages:

- Insensitive to neutral background (e.g. γ -ray)
- More information than other methods:
 - Full 4-momentum and charges of two β -rays
 - Decay vertex position

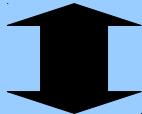


- Good background rejection:
- More information (E-spectrum of single β , angular correlation) to constrain New Physics beyond the SM (if $0\nu\beta\beta$ observed)

Disadvantage:

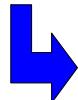
For better resolution:

Need to have ***less material*** inside of the tracking volume



For better statistics:

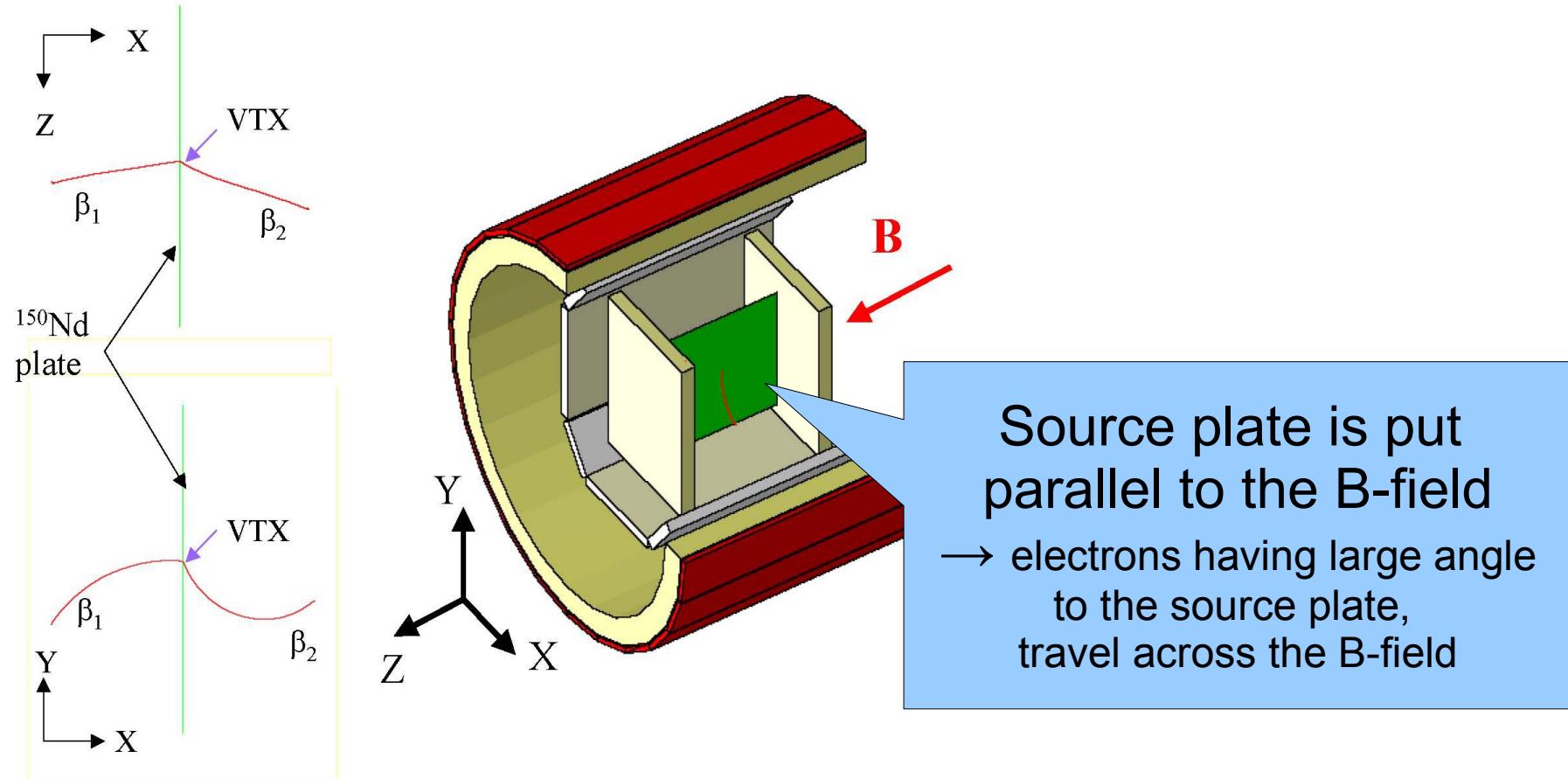
Need to have ***more source*** inside of the tracking volume



hard to increase source weight

DCBA: method

- have source plate(s) inside of the tracking volume
Source plate: ^{100}Mo (^{150}Nd in future)
- emitted two electrons make helical trajectories inside of the tracking volume
- reconstruct momenta of two electrons



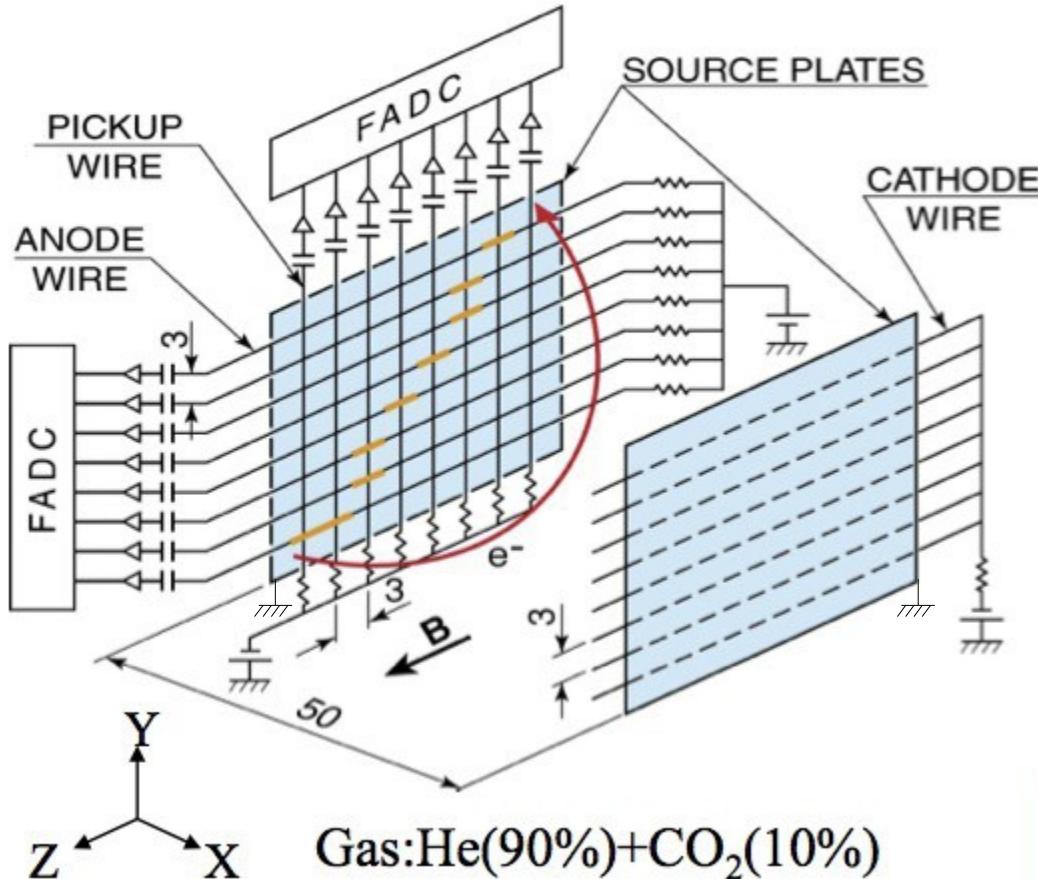
DCBA: track reconstruction method

Reconstruct position:

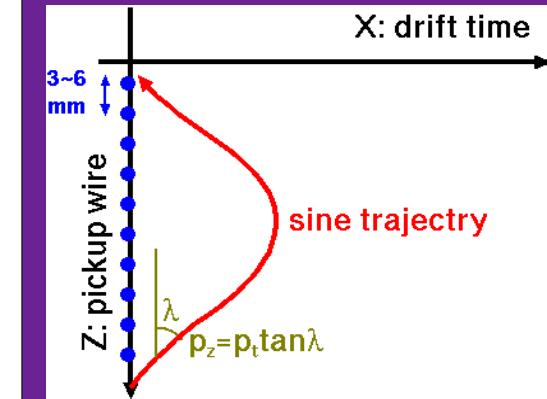
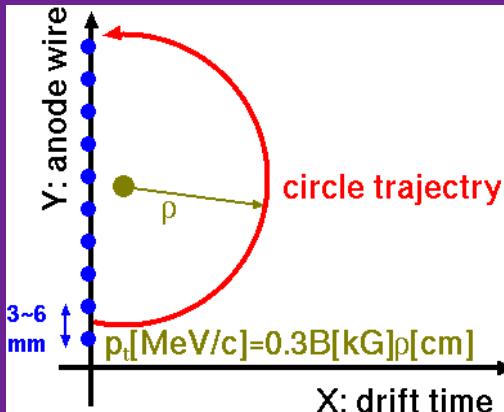
X: drift time

Y: hit position of the anode wire

Z: hit position of the pickup wire



Reconstruct momentum:

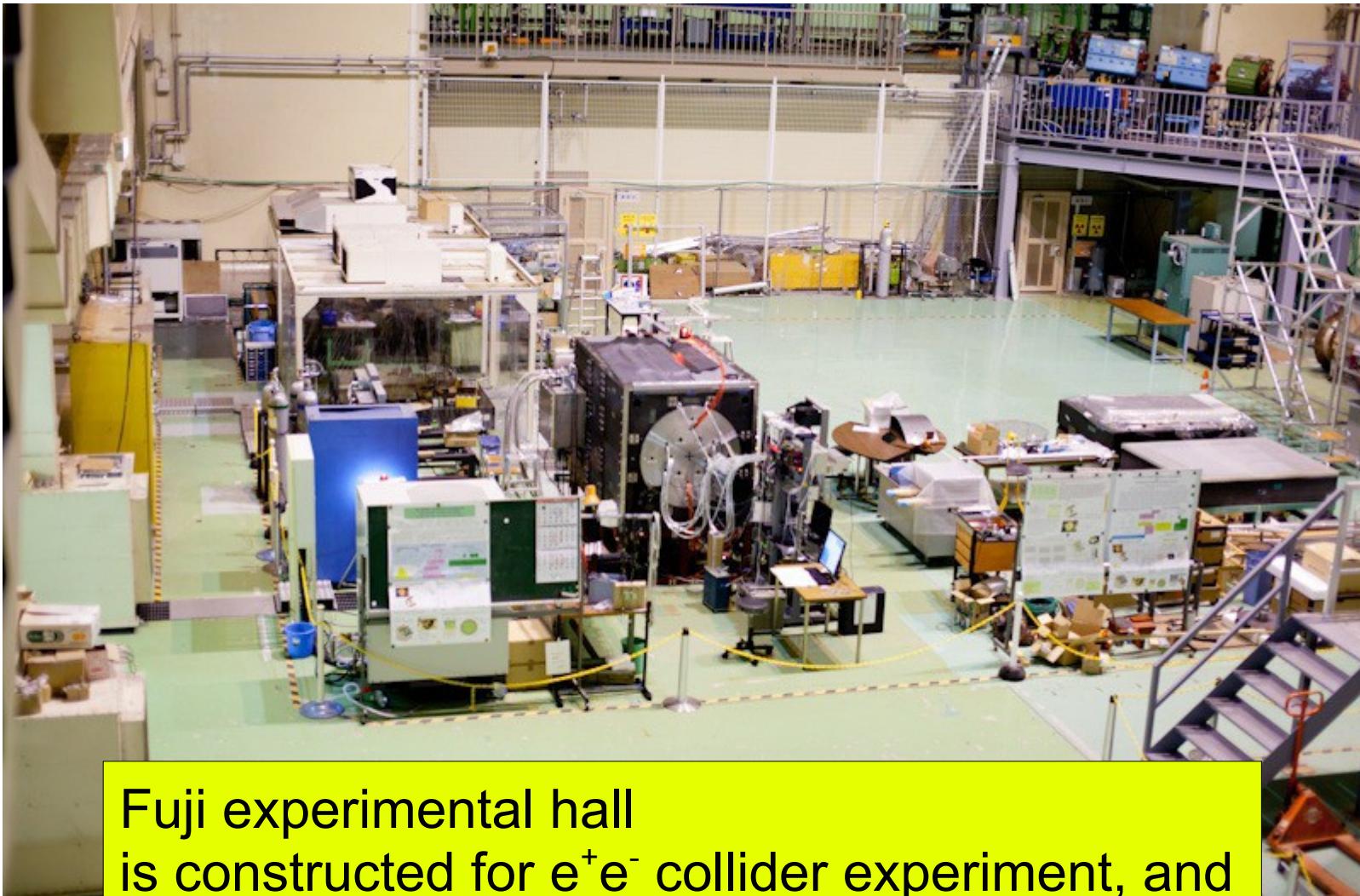


Kinetic energy

$$\begin{aligned} T &= \sqrt{p_t^2 + p_z^2 + m_e^2} - m_e \\ &= \sqrt{(0.3B\rho)^2(1+\tan^2\lambda)} + m_e^2 - m_e \\ &= \sqrt{(0.3B\rho)^2/\cos^2\lambda + m_e^2} - m_e \end{aligned}$$

DCBA experiment

DCBA experiment is performed at Fuji-experimental hall @ KEK



Fuji experimental hall
is constructed for e^+e^- collider experiment, and
is ***NOT*** underground facility

History and Future Plan

2005 DCBA

- charge dividing
- 6 mm pitch wires (xy + xz)

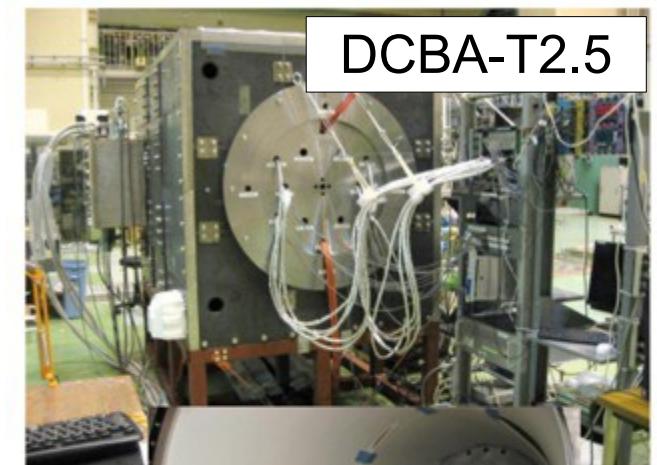
2007 DCBA-T2

- ^{100}Mo source (natural Mo 30g)
- 0.6 - 0.8 kG magnetic field
- Normal conducting magnet:
9h/day operation (Mon.-Fri)



2011 DCBA-T2.5

- 6 mm pitch wires (xy + xz)
- ^{100}Mo source (natural Mo 30g)
- 0.8 kG magnetic field
- super-conducting magnet:
24h nonstop operation



now
2014 DCTA-T3

- 3 mm pitch wires (xy + xz)*8
- ^{150}Nd (5.6% in natural Nd_2O_3)
- B=3 kG at the maximum

- ^{82}Se ^{150}Nd (enriched)
several 10 kg

2017 MTD
(tentative name)

DCBA-T2 Chamber installed
into the DCBA-T3 SC-Magnet

DCBA-T2.5

2005 DCBA

- charge dividing
- 6 mm pitch wires (xy + xz)

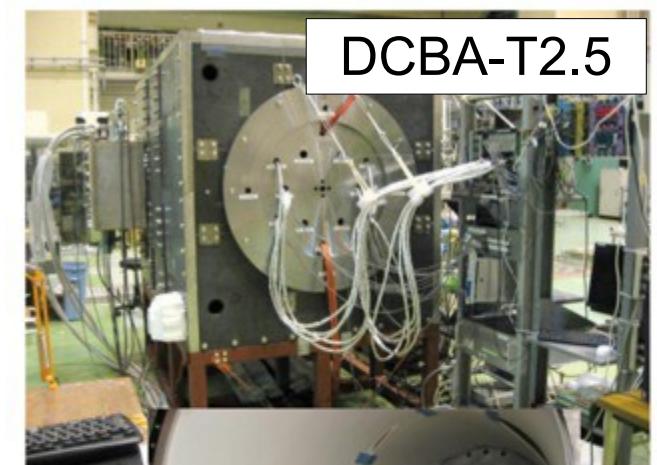
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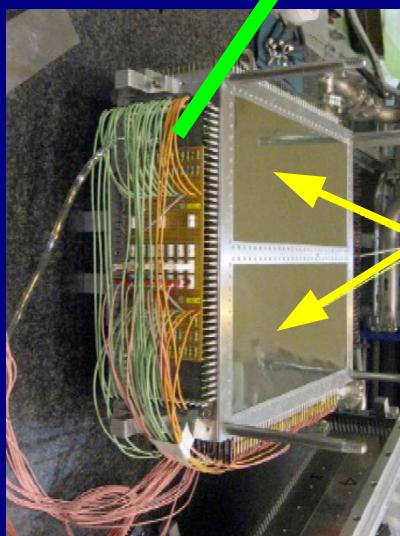
2017 MTD
(tentative name)

DCBA-T2 Chamber installed
into the DCBA-T3 SC-Magnet

DCBA-T2.5

DCBA-T2 chamber is installed in the DCBA-T3 magnet

DCBA T2 Chamber



Natural Mo source plate:

- 280mm x 130mm
- $\times 50\mu\text{m}$
- 45mg/cm^2
- total 30g
- ^{100}Mo : 9.6% in the plate (0.03 mol)



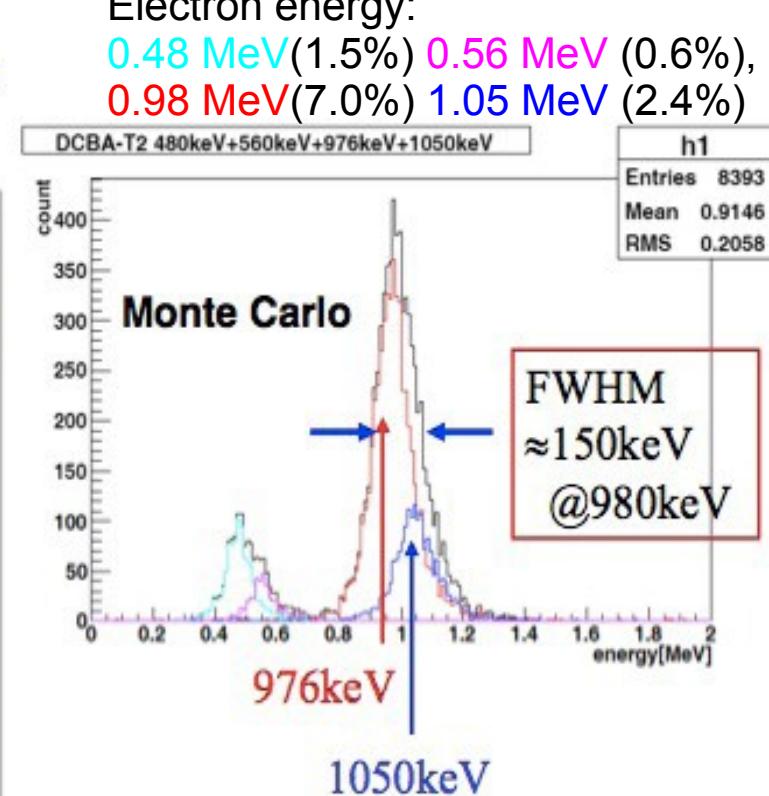
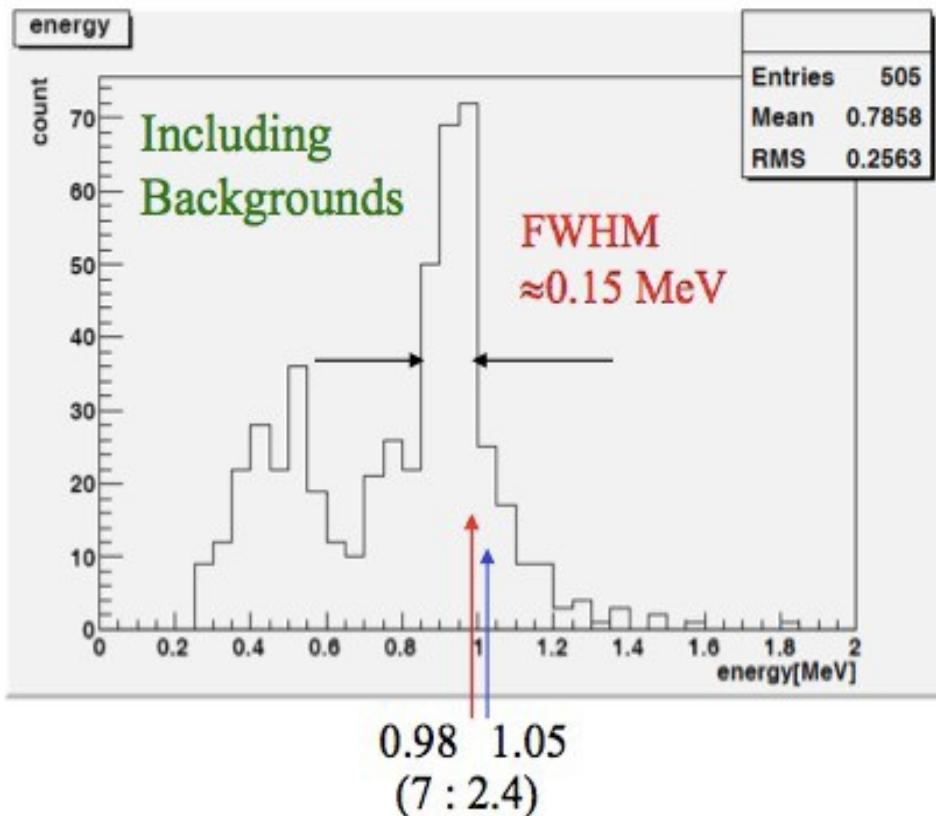
DCBA-T3 Magnet:

- Super-Conducting solenoid
- 24 hour operation
- $B \sim 0.6\text{-}0.8\text{kGauss}$ for T2.5

July 2011 – Sep. 2012: took data @ $B=0.8\text{kG}$
Sep. 2012 – : taking data @ $B=0.6\text{kG}$

Energy resolution of DCBA-T2 (& T2.5)

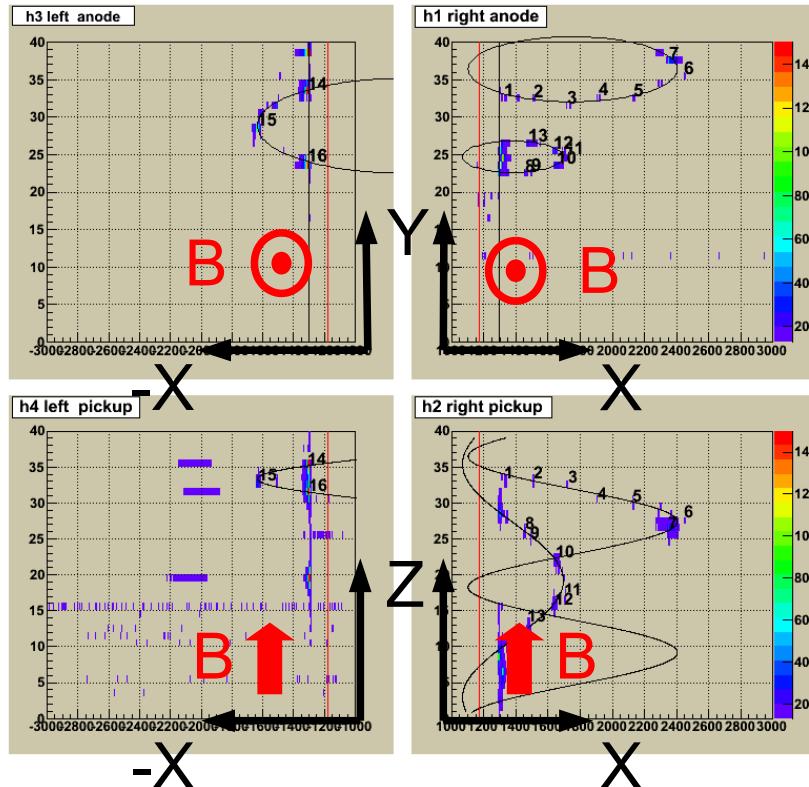
Energy spectra of internal conversion electrons from ^{207}Bi



Chamber conditions
 $\text{He}(90\%) + \text{CO}_2(10\%)$ 1 atm
 $B=0.8 \text{ kG}$
Wire pitch=6 mm

Energy resolution: $\sim 0.15 \text{ MeV}$ (FWHM)

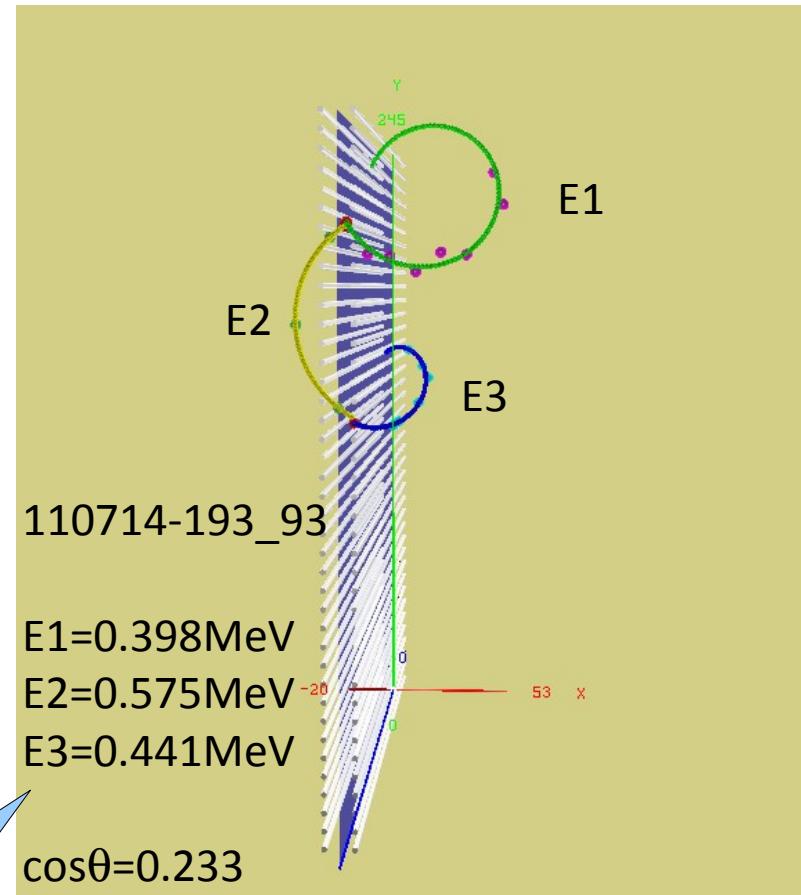
DCBA-T2.5: A $2\nu\beta\beta$ Signal Candidate



Current analysis method:

Eye scan based analysis
using graphical tools

Understand the event topology



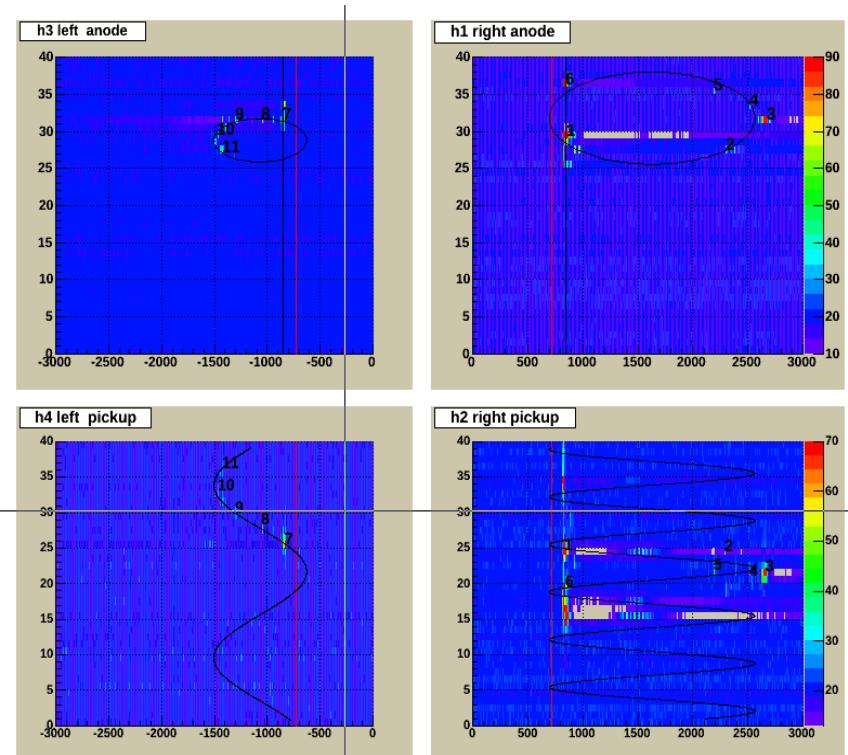
Vertex point

E1 E2

Y 206.5mm 205.5mm

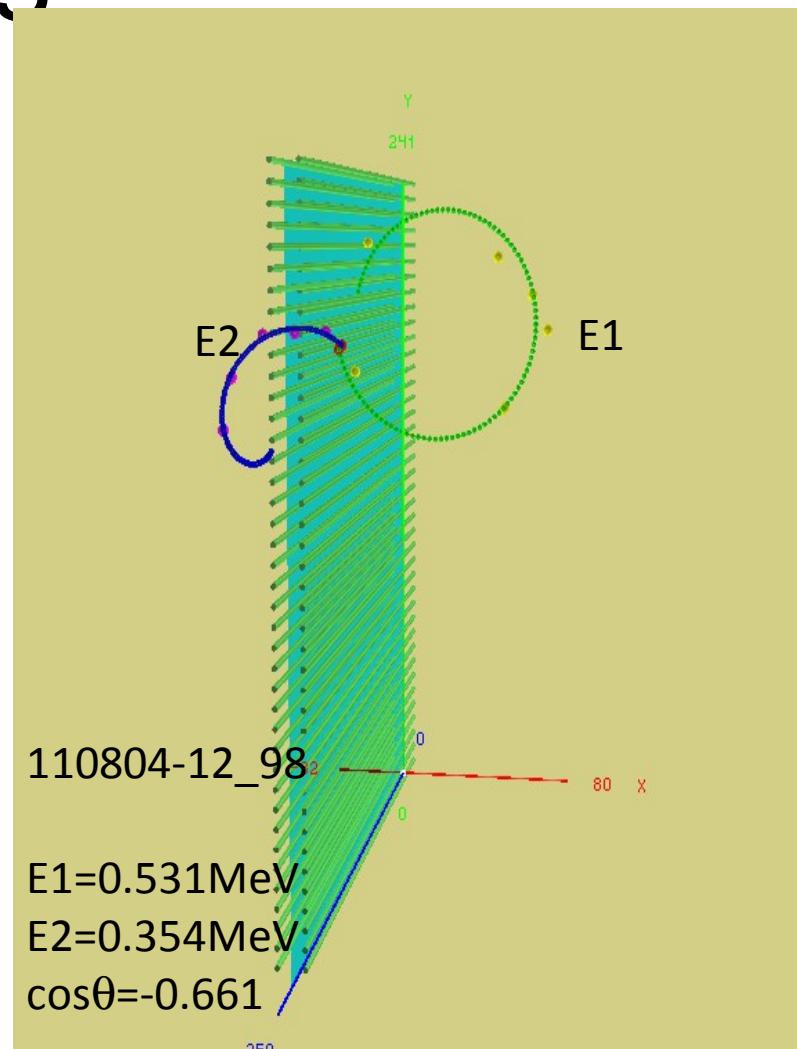
Z 210.7mm 213.3mm

Another $2\nu\beta\beta$ signal candidate



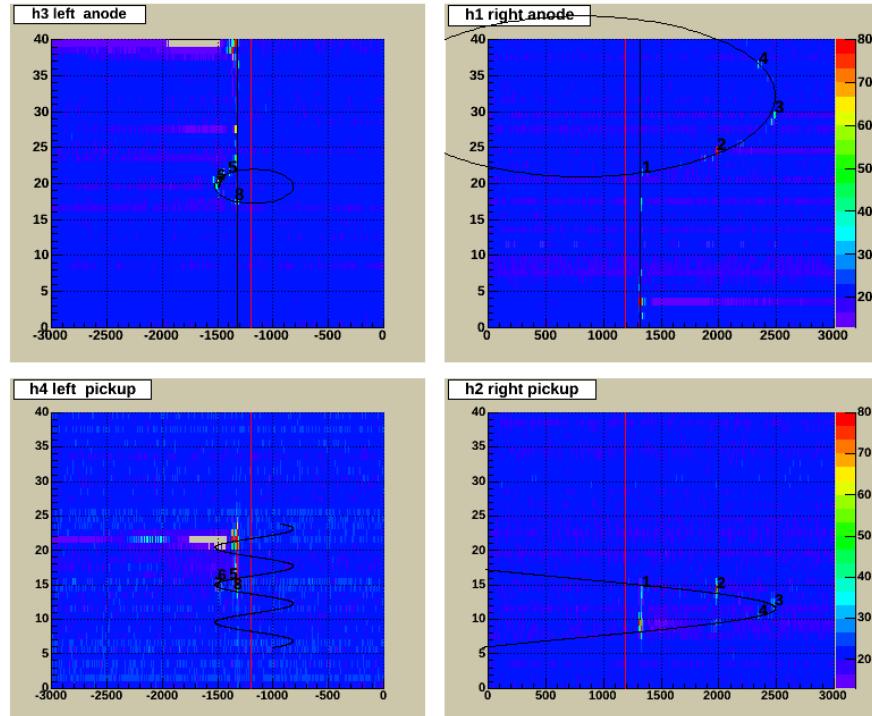
Characteristics of
the signal candidate

1. trajectory of the two tracks looks like inverse “S” shape
2. vertex points of two tracks are consistent



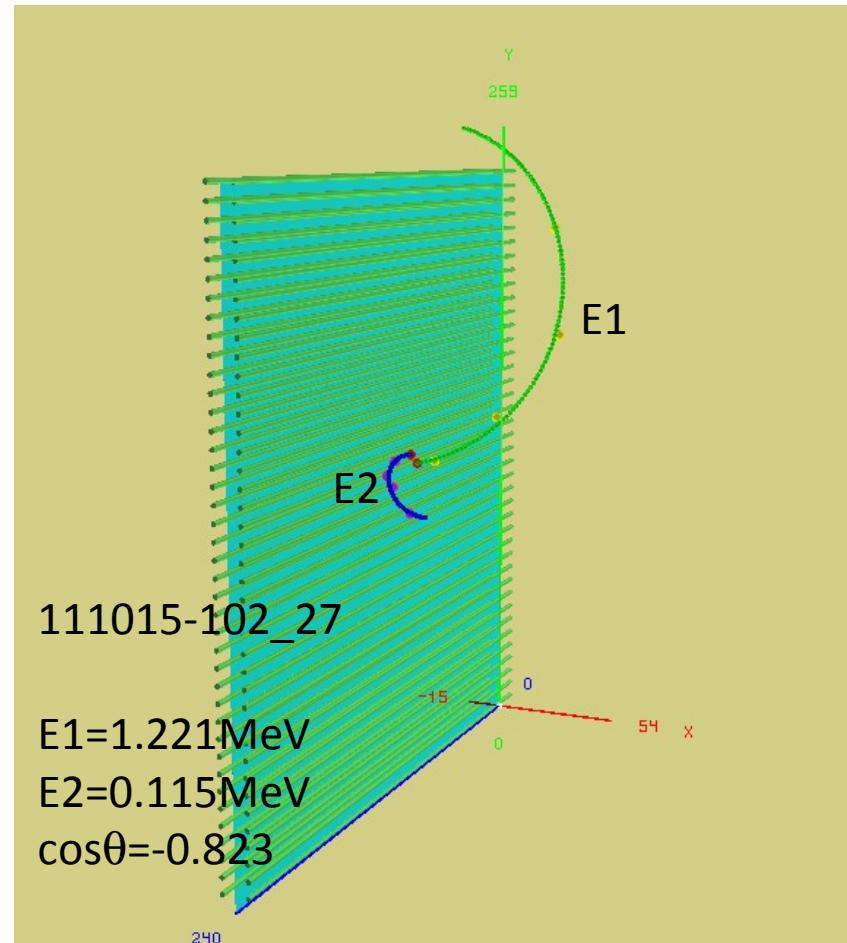
Vertex point
E1 E2
Y 183.0mm 183.9mm
Z 151.7mm 146.3mm

Yet another signal candidate



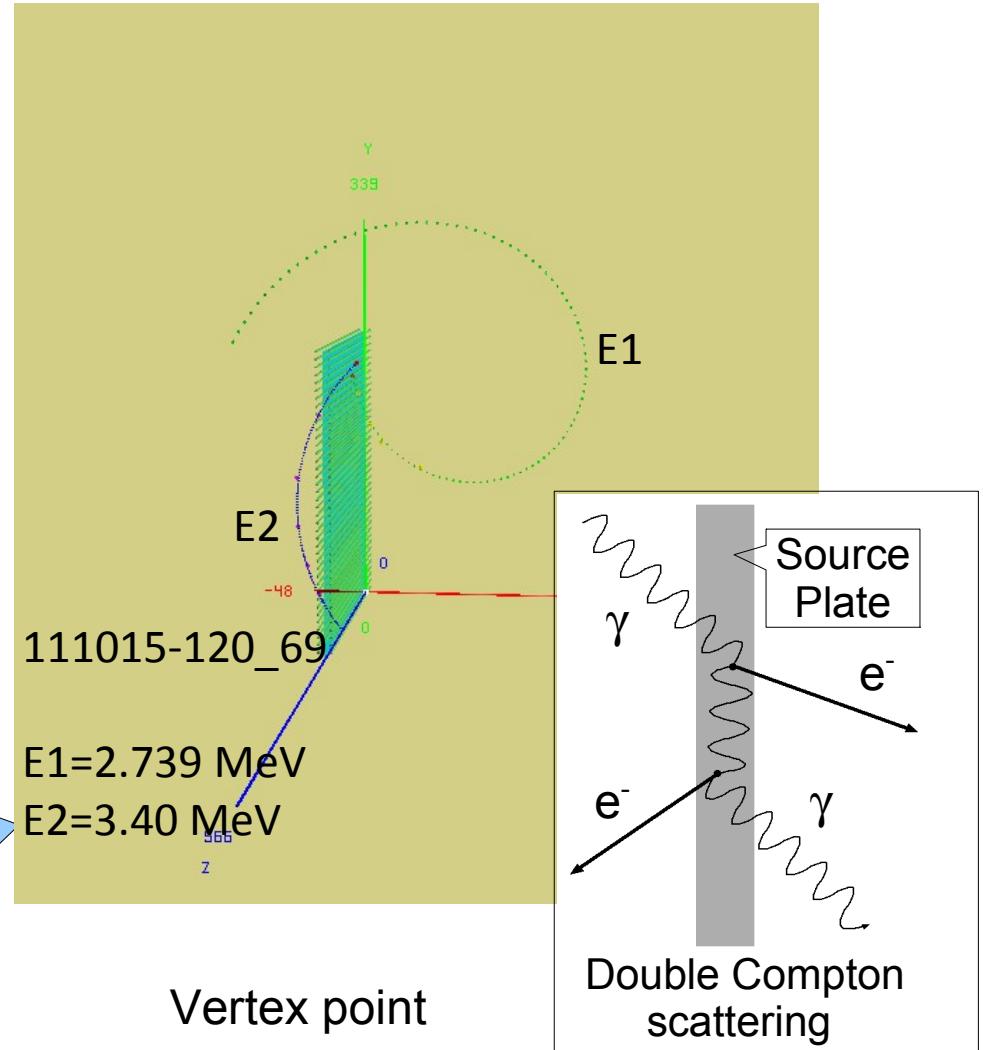
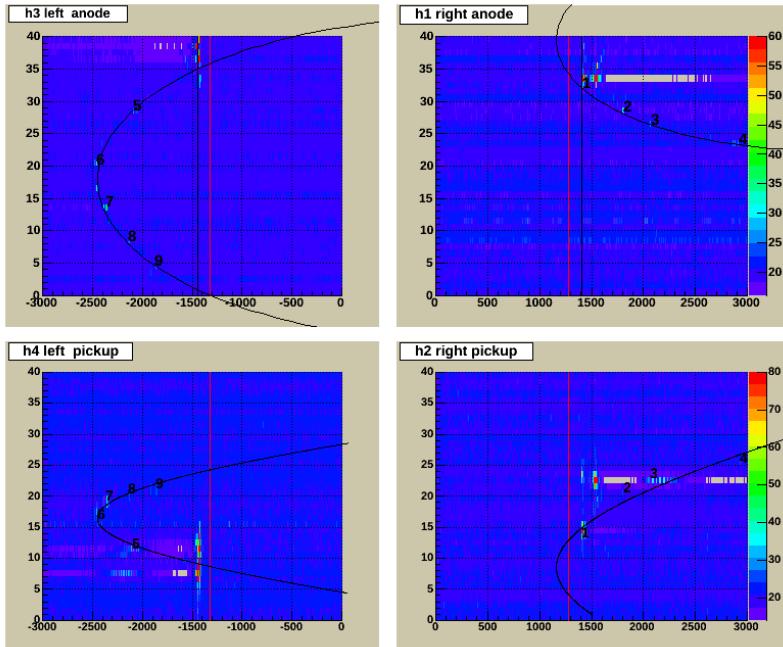
Characteristics of
the signal candidate

1. trajectory of the two tracks looks like inverse “S” shape
2. vertex points of two tracks are consistent



Vertex point
E1 E2
Y 127.4mm 131.8mm
Z 91.3mm 97.6mm

A typical background event



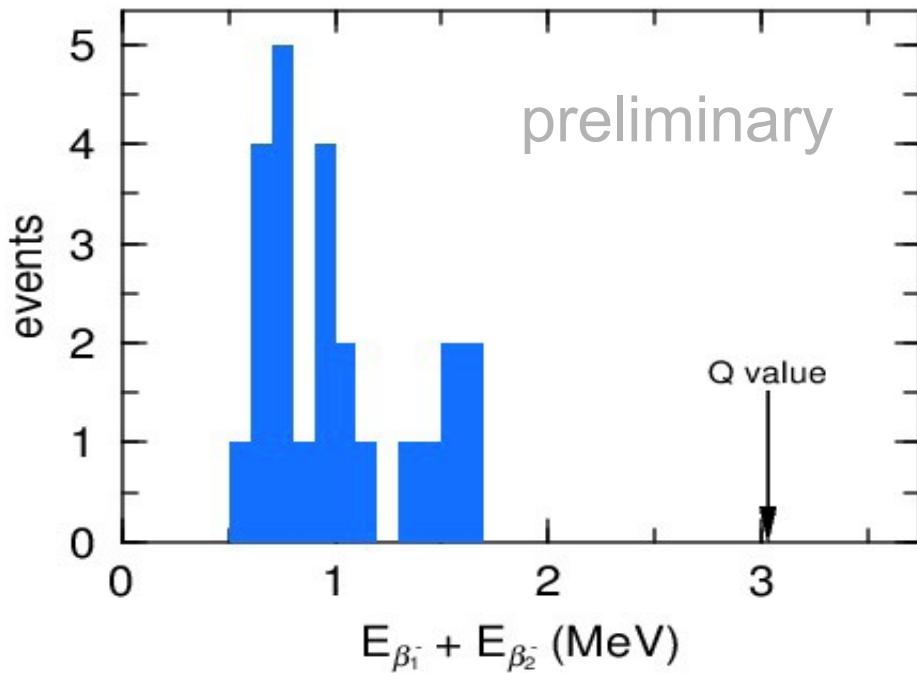
Background event of
Double Compton scattering

1. Energy is too large
($^{100}\text{Mo} \rightarrow ^{100}\text{Ru}$: Q-value=3.0MeV)
2. Vertex point is inconsistent
between two tracks

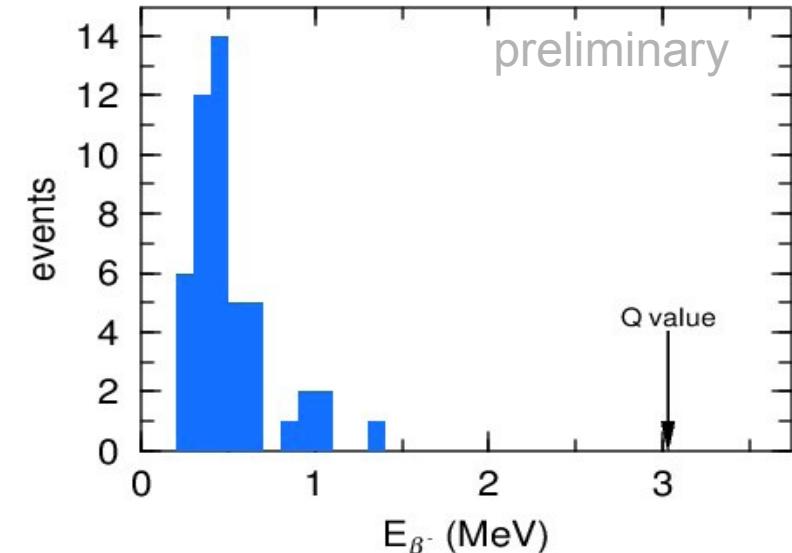
	Vertex point	E1	E2
Y	205.9mm	214.9mm	
Z	77.4mm	52.1mm	

DCBA-T2+T2.5 preliminary result

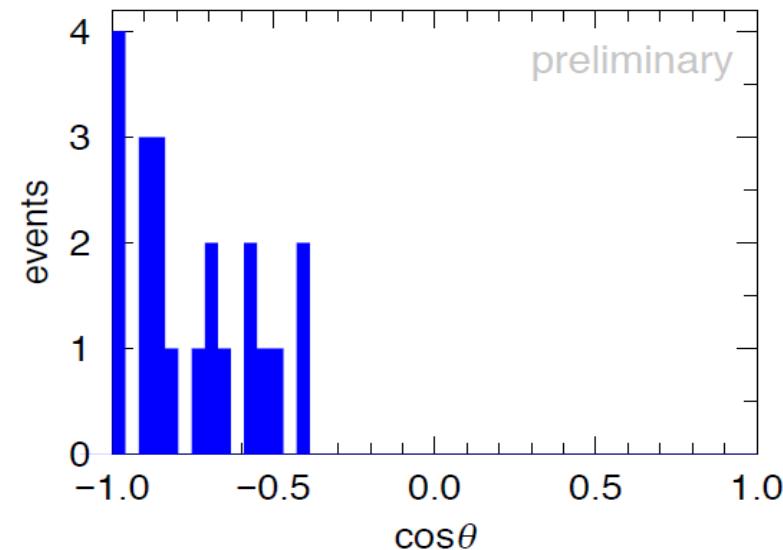
DCBA ^{100}Mo $\beta\beta$ decay result



DCBA ^{100}Mo $\beta\beta$ decay result



angular correlation of ^{100}Mo $2\nu\beta\beta$ by DCBA



Three distributions can be measured:

- Total energy($E_{\beta_1} + E_{\beta_2}$) distribution
- Single β energy ($E_{\beta_1 \& \beta_2}$) distribution
- angular correlation b/w two β s
(Only a part of T2.5 data is included)



Currently, we have much more events.
Analysis is ongoing.

DCBA-T3

2005 DCBA

- charge dividing
- 6 mm pitch wires (xy + xz)

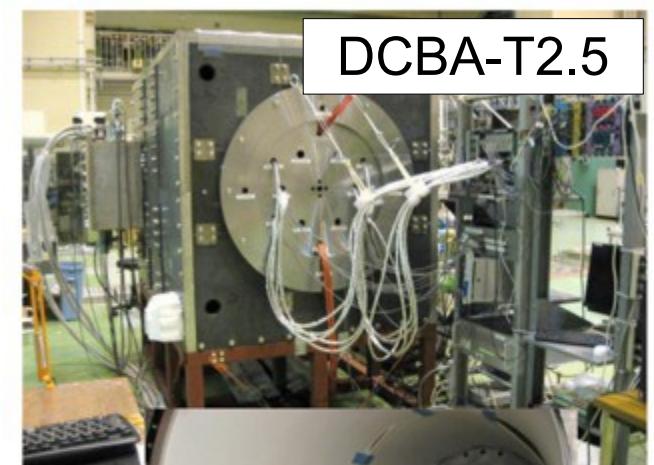
2007 DCBA-T2

- ^{100}Mo source (natural Mo 30g)
- 0.6 - 0.8 kG magnetic field
- Normal conducting magnet:
9h/day operation (Mon.-Fri)



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- 6 mm pitch wires (xy + xz)
- ^{100}Mo source (natural Mo 30g)
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24h nonstop operation



now

2014 DCTA-T3

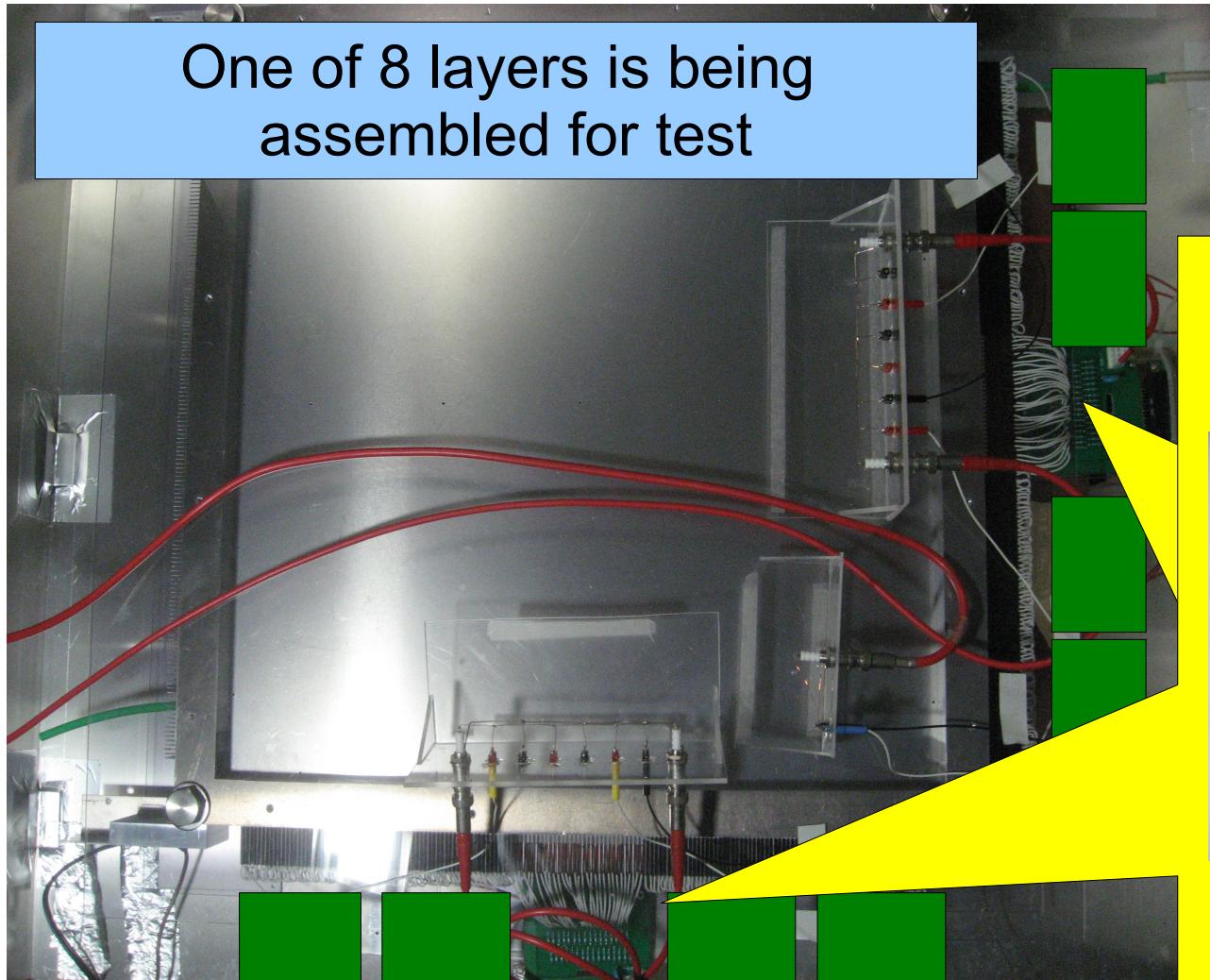
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- B=3 kG at the maximum

- ^{82}Se ^{150}Nd (enriched)
several 10 kg

2017 MTD
(tentative name)

DCBA-T2 Chamber installed
into the DCBA-T3 SC-Magnet

DCBA-T3 Chamber & Front-end electronics

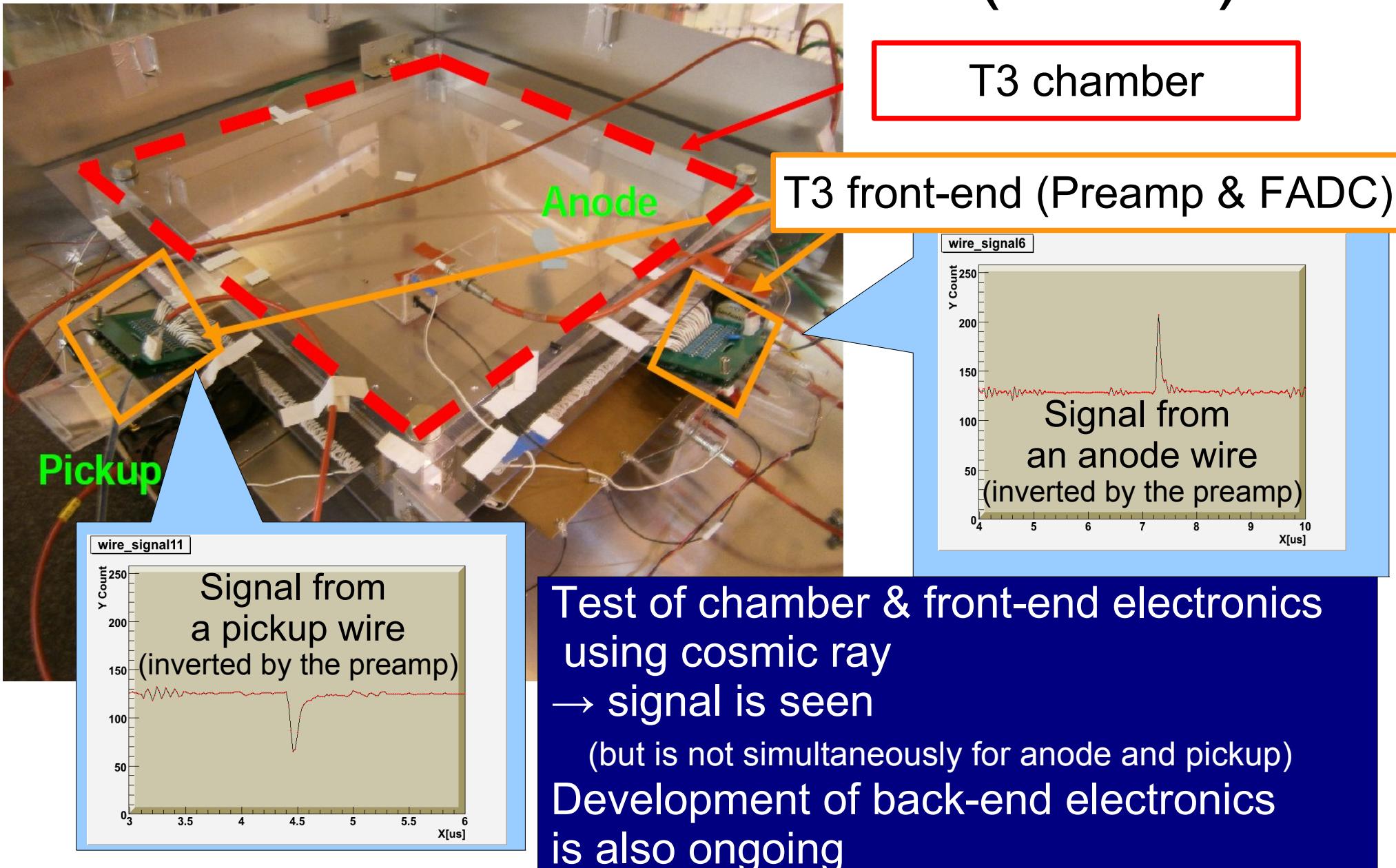


	T2	T3
# of wires	40	160
Wire pitch	6mm	3mm



Expected momentum resolution: <100keV
by fine pitch(6mm→3mm) readout

DCBA-T3 Chamber & Front-end electronics (cont'd)



Next generation experiment: MTD

2005 DCBA

- charge dividing
- 6 mm pitch wires (xy + xz)

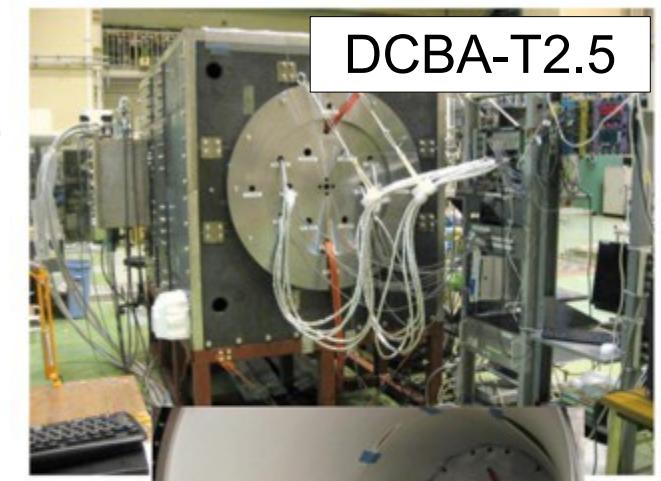
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now

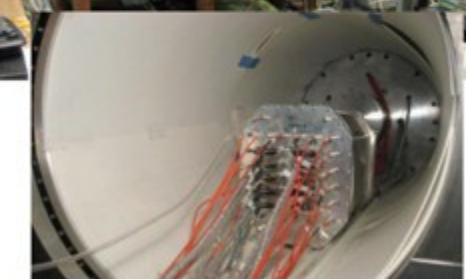
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several 10 kg

2017 MTD
(tentative name)

DCBA-T2 Chamber installed
into the DCBA-T3 SC-Magnet

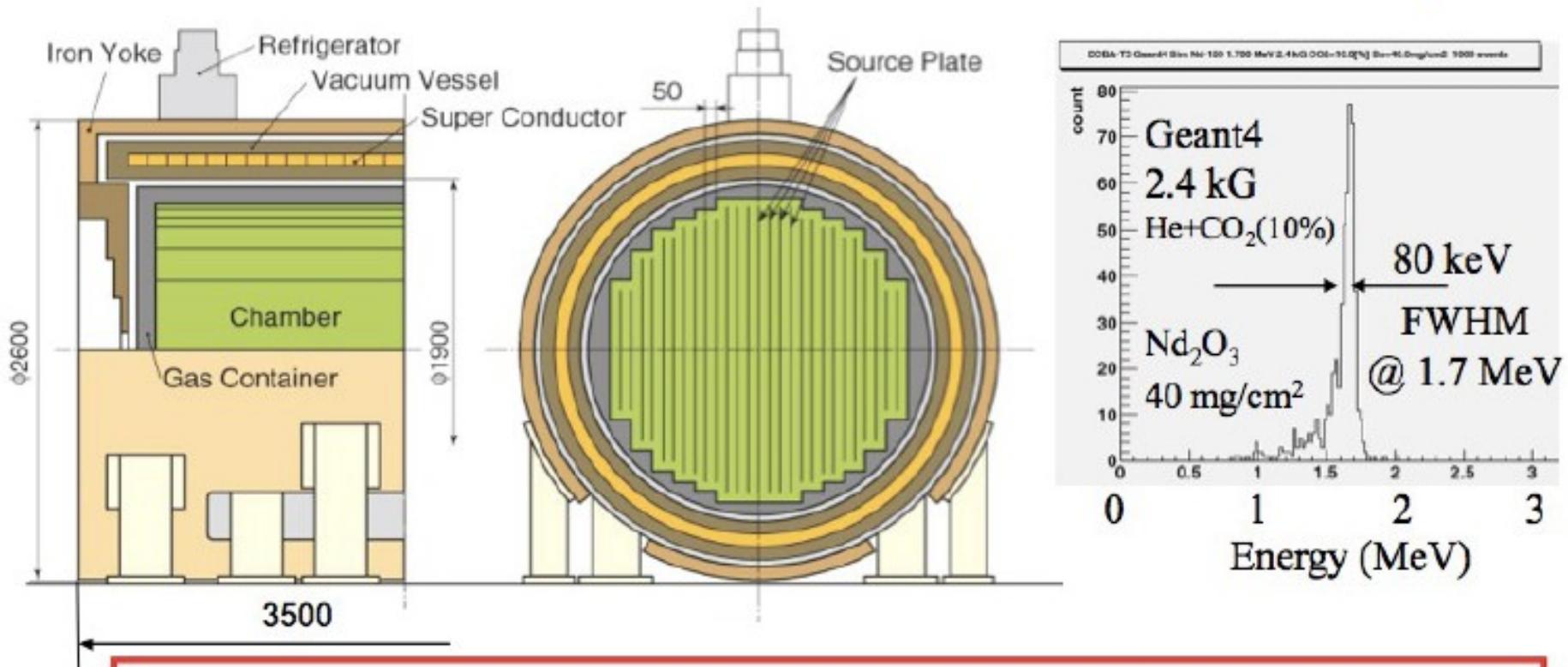


MTD: Overview

Magnetic Tracking Detector (tentative name)

Chamber cell : the same as DCBA-T3, Source plate: $80 \text{ m}^2/\text{module}$

Thickness: 40 mg/cm^2 , Source weight: 32 kg/module 27 source plates

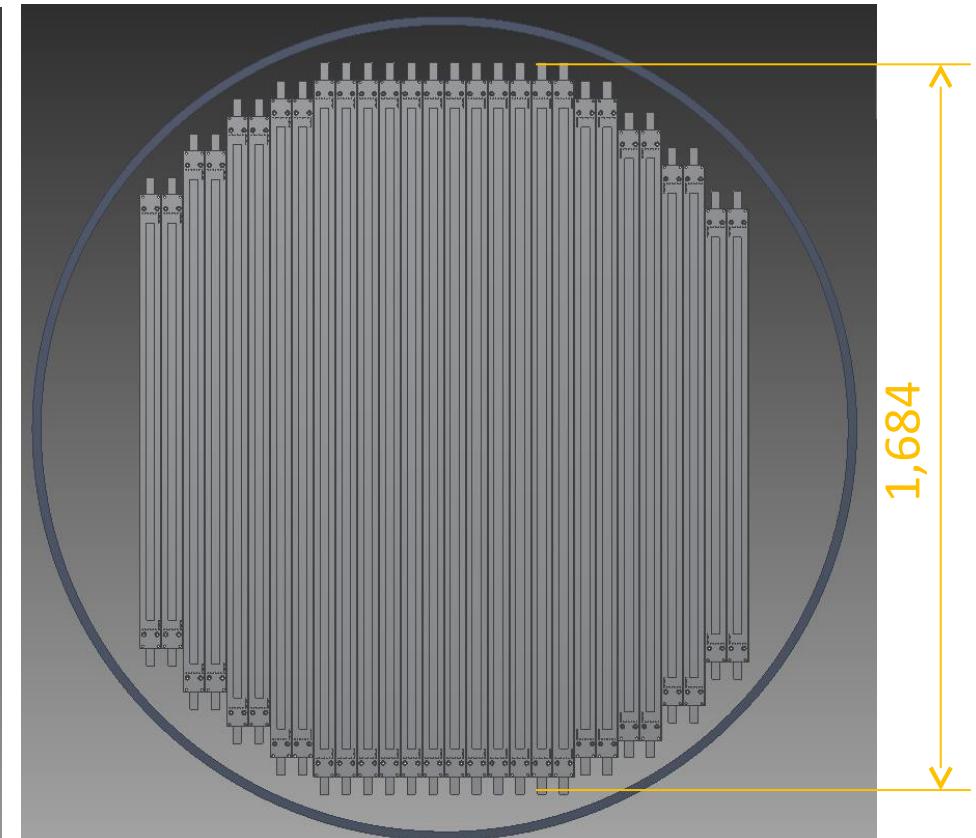
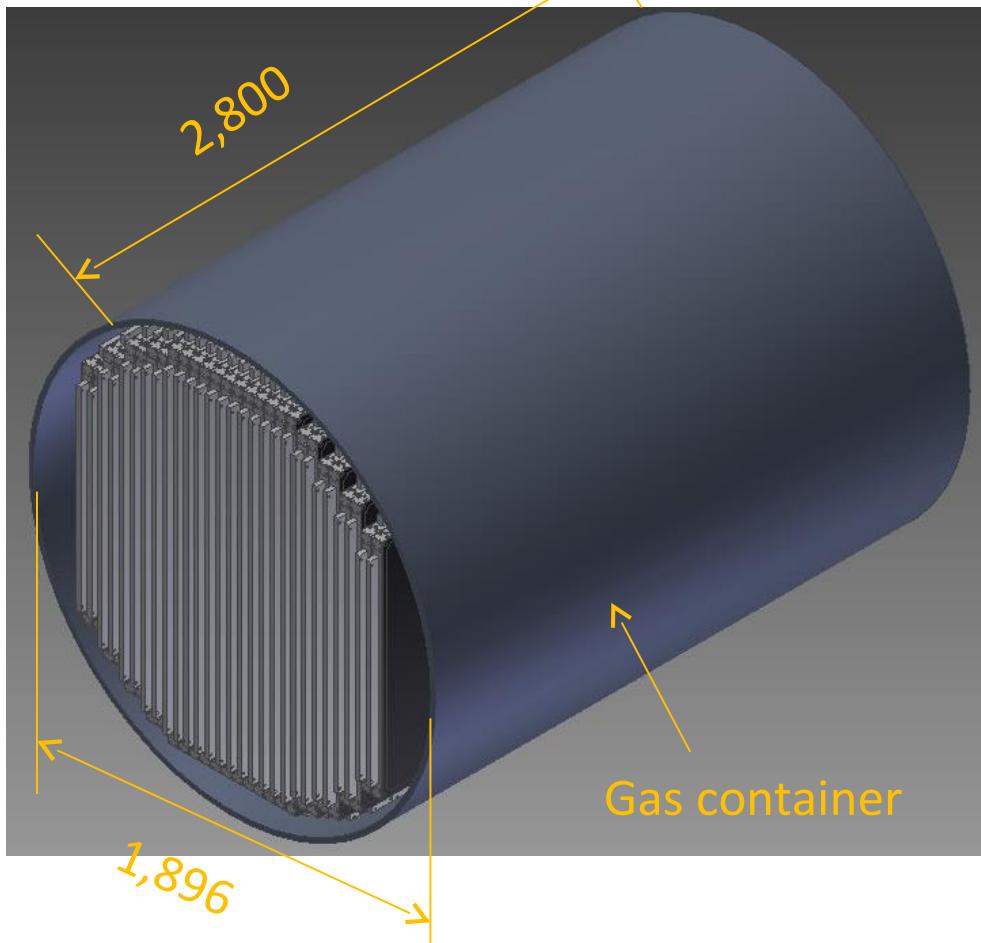


Expected Energy Resolution

$$\frac{\text{FWHM}(E_{sum}) = \sqrt{2} \times 80\text{keV}}{Q_{\text{Nd-150}}(3370\text{keV})} \approx 3.4\%$$

MTD: R&D status

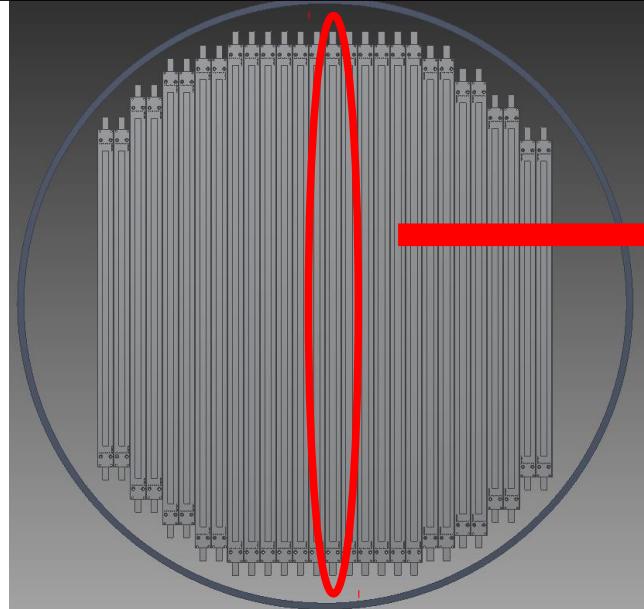
Drawing of MTD drift chambers and Gas Container



Design study of the mechanical structure has been started

MTD: R&D status (cont'd)

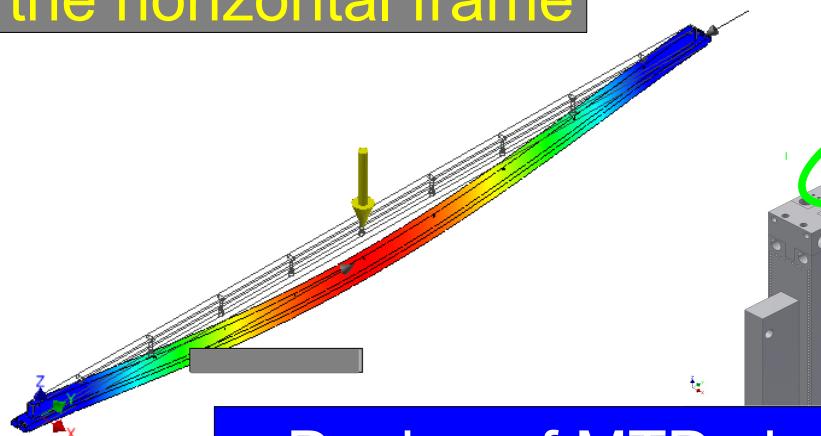
Drawing of MTD chambers



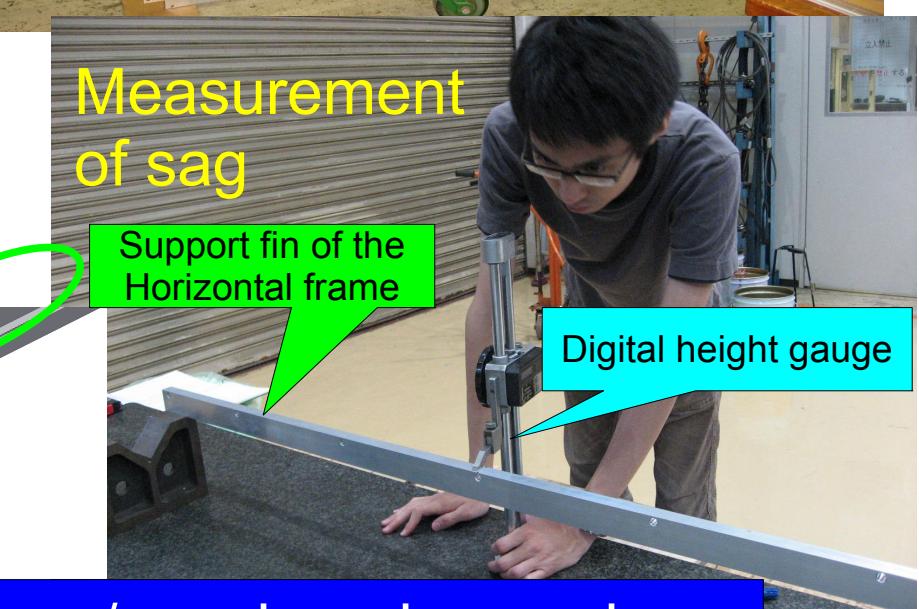
Production of a chamber frame mock-up



Calculation of sag
of the horizontal frame



Measurement
of sag



Design of MTD chamber w/ mock-up is ongoing

Summary

DCBA is track-based $\beta\beta$ -decay experiment:

- reconstruct full 4-momentum of two β -rays
- advantage: more information, less background

DCBA-T2.5 is now running:

- 24 hour operation with Super Conducting solenoid magnet
- 20k triggers/day, 1 signal candidate/day from ^{100}Mo source
 - Data taking and analysis is ongoing

DCBA-T3 is under development:

- Momentum resolution: < 100keV with 3mm pitch
- Development of chamber and readout electronics is ongoing

MTD is the next generation experiment:

- Aim to observe $0\nu\beta\beta$ from ^{150}Nd and/or ^{82}Se source
- If $0\nu\beta\beta$ is found, MTD can also provide:
 - E-spectrum of single β & angular correlation b/w two β s
- Design study of the mechanical structure is ongoing